REMARKS/ARGUMENTS

Claims 1 to 22 are currently pending in this application. No claims have been amended with this response, and no new matter has been added with this response. Claim 21 has been canceled.

Rejections Under 35 U.S.C. §101

The Examiner rejected claims 21 and 22 as being duplicates. Applicants have cancelled claim 21, thereby obviating this rejection.

Rejections Under 35 U.S.C. §103(a)

The Examiner rejected all of the pending claims as unpatentable under 35 U.S.C. §103(a) over either Odagawa et al. (USPN 5,647,921) or Arakawa et al. (USPN 4,768,458) in view of the teachings of Liebermann (USPN 4,791,979). Applicants respectfully traverse this rejection.

As Applicants discussed in their previous response, the current invention is directed to an improved process for producing thick continuous sheet sections of amorphous metal. To accomplish this Applicants have modified conventional continuous sheet casting processes to include a stabilization step that carefully controls the temperature of the molten alloy so that the exact viscosity of the liquid alloy can be controlled prior to introduction onto the sheet casting roller.

This runs counter to the prior art systems, such as those described by Odagawa et al. and Arakawa et al., which focus entirely on the mechanics of the casting process such as roller speed, slit size, slit geometry, cooling rate, etc. As a result, these conventional continuous casting processes are only capable of forming sheets having thicknesses below 100 μm. For example, Odagawa et al. recite twenty-three separate examples of exemplary amorphous alloy ribbons the thickest of which is 39 μm. Odagawa et al. never disclose or even suggest a step of stabilizing the molten alloy,

either around or below the melting temperature, before casting to ensure a viscosity between 0.1 and 1,0000 poise as required by the current application, and rely entirely on controlling the mechanics of introducing the molten metal onto the sheet roller. For example, Odagawa et al. in discussing the process of the '921 patent never describe preferred viscosity levels, but rather describe the surface velocity of the rotating wheel, the injection pressure of the molten alloy, the casting temperature, the slot width at the nozzle tip and the gap between the nozzle tip and the cooling wheel. (See, e.g., Odagawa et al, col. 3, lines 1 to 60; and cols. 4 and 5.)

Likewise, the Arakawa et al. patent only teaches the production of thin ribbons of amorphous alloy having thicknesses no greater than 0.05 mm. Arakawa et al. never teach a step of stabilizing the viscosity of the molten amorphous material to ensure better casting and the availability of thicker sheets, again focusing on forming very well defined thin ribbons of amorphous alloy by controlling the speed of the roller, the geometry of the nozzle, and its relationship to the cold roller. Moreover, Arakawa et al. specifically teach that the method disclosed in their patents is preferred for use with very thin sheets of amorphous alloy, stating:

> In the present invention, the restriction of the front lip width W_F as $W_F/W \leq 0.8$ makes the upper surface of the melt puddle rather free and makes the surface conditions of the metal sheet excellent. The top surface roughness Rz (by JIS BO 601-1970) can be improved. Especially the improvement of the top surface conditions for a rather thin metal ribbon having a thickness of 25 μm or less is remarkable. (Arakawa et al., col. 3, lines 13 to 21.)

Indeed, the background of the Arakawa et al. patent seems to suggest that the process is focused, not on forming thick ribbons, but on improving the process of making very thin ribbons, stating in relevant part:

> However, in the above-mentioned processes, three were drawbacks that the produced [sic] amorphous metal ribbon, especially a ribbon having a thickness of about 25 μm or less might be provided with scratches on the surface or with a rough surface. (Arakawa et al., col. 1, lines 60 to 64.)

The reason these past devices have focused on "mechanistic" methods of controlling the flow rests in the fact that they are casting very thin sheets. With thin sheets it is possible to increase the speed of the casting wheel while maintaining a sufficient quench rate, thereby allowing the use of very low viscosity alloy melts. However, to cast thicker sheets it is necessary to slow the wheel down. At these slow wheel speeds the molten alloy simply cannot be "held" on the wheel by these "mechanistic means". This distinction, and the importance of controlling the viscosity of the molten alloy through the stabilization process, is made clear by Applicants in the description of the current invention. For example, Applicants explain that were one to attempt to form the thick sheet sections of the current invention using a conventional process, the lack of control over the viscosity would lead to unstable casting resulting in discontinuities in the sheet. For example, Applicants write:

> Although it is possible to obtain quench rates at lower velocities, there are many difficulties encountered. For example, at typical melt viscosities and low wheel rotational speed it is not possible to reliably sustain a continuous process. As a result, the melt may flow too fast through the orifice slit and spill over the wheel, precluding a stable melt puddle and a steady state moving solidification front. Although, some remedies can be implemented, such as reducing the orifice slit size, generally this is not a practical solution because the molten metal would erode the opening of such a small orifice very quickly. (Specification, page 2, lines 13 to 20.)

However, the Examiner dismisses Applicants ' previous arguments by stating the "since the puddle of the bulk solidifying amorphous alloy on the chill surface must be in a stable condition, it would have been obvious to obtain an appropriate viscosity of the casting alloy through routine experimentation such that the injected melt will form a stable puddle." (Office action, page 2.) To support this assertion the Examiner sites to the Liebermann patent, and specifically to col. 4, lines 17 to 21 of that patent. Applicants reproduce this section of the text below:

> **In conventional rapid solidification casting devices, the downstream top surface of the melt puddle is generally supported by a downstream lip member, such as the lip member taught by U.S. Pat. No. 4,221,457 to Narasimhan. Any imperfections on the downstream lip member, however, can cause undesired marks or striations on the top surface of the cast strip. These marks and striations undesirably degrade the strip quality. In addition, when casting a molten metal alloy which has a low viscosity of less than about 0.01 Pascal-sec. (Pa-sec), undesirable "splash" marks can form on the top surface of strip 22.**

While this section of text does mention metals having viscosities of "about 0.01 Pascal-sec", the section of the patent cited by the Examiner does not, as asserted, "show the conventionality of maintaining the viscosity of the molten metal [to] not less than 0.01 Pascal.sec." (Office action, page 3.) First, the quoted section does not discuss any range within which the viscosity of the alloy should be maintained. The text instead assumes that the reader will be casting "below" this viscosity, which Applicants' would note is already at the very low end of their proposed viscosity scale (0.1 poise). Indeed, a careful reading of the sentence in question makes it clear that the quoted section is really only pointing out a problem associated with the low viscosity alloys, namely, that unless the appropriate "mechanistic" means are brought to bear that the casting will have flaws.

This reading is supported by an examination of the rest of the Liebermann patent, which is remarkably similar in form and function to the Odagawa et al. and Arakawa et al. patents. First, as with the Odagawa et al. and Arakawa et al. patents, the

Liebermann patent is directed to cast sheets that are at least a factor of two thinner than those claimed in the current application. Specifically, the only example provided by Liebermann has a thickness of 0.051 mm. (Liebermann, col. 6, line 30.) Second, the Liebermann patent never discusses the idea of stabilizing the viscosity of an alloy within a certain range to ensure casting quality, as required by the claims of the current invention. Instead, as in the Odagawa et al. and Arakawa et al. references the Liebermann patent discusses how the "mechanism" of the device should be adjusted to ensure casting quality. Indeed, the entire thrust of the Liebermann patent is directed to a mechanism for avoiding spillage of the alloy around the sides and back of the nozzle mechanism by providing a constraining jet of gas. For example, Liebermann summarizes the invention as follows:

> **[57] ABSTRACT**
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> **A method and apparatus for casting rapidly solidified metallic strip includes a nozzle mechanism which has an orifice for directing a stream of molten metal onto a movable quench surface. An upstream constraint mechanism constrains an upstream portion of a melt puddle formed on the quench surface by molten metal from the molten metal stream. A side constraint mechanism constrains two, opposite side portions of the melt puddle, and a downstream constraint mechanism provides a selected gas pressure, constraining force against a downstream, top surface of the melt puddled.**

As discussed above, these "mechanistic" adjustments are just the type of means Applicants specifically teach away from in the instant application.

In short, apart from yet another new nozzle arrangement, the Liebermann patent adds nothing to the teachings of the Odagawa et al. and Arakawa et al. patents. And in particular, the Liebermann patent never discusses, teaches or even suggest that one should stabilize the temperature of the amorphous metal to ensure a viscosity that would allow successful casting of thick continuous sheets.

In conclusion, all of the prior art patents cited by the Examiner are focused on adjusting the roller speed and nozzle alignment/design to ensure appropriate casting of

thin sheets of metals. These are precisely the type of conventional casting techniques that the current invention was designed to modify to allow for the casting of thicker amorphous sheets. Accordingly, Applicants submit that one of skill in the art, having read the combined teachings of the Odagawa et al. and/or Arakawa et al. and Liebermann references, would not have had any motivation to include a viscosity stabilization step, as required by the claims of the current application, much less a motivation as to what range of viscosity should be used in the process, but rather would have been motivated to attempt changes to the roller speed, nozzle width, nozzle gap, etc.. As such, Applicants believe the combination of the cited references would have reinforced the need to resort to such "mechanisitic" manipulations, leading one of ordinary skill further away from Applicants own casting technique.

In summary, given the process parameters repeatedly taught by the cited prior art, one of skill in the art would have had no motivation to modify those same references to produce the method claimed in the current application. Accordingly, Applicants submit that the claimed invention cannot be said to be obvious in light of the combination of Odagawa et al. and/or Arakawa et al. and Liebermann.

Conclusion

In view of the foregoing amendment and response, it is believed that the application is in condition for further examination. If any questions remain regarding the allowability of the application, Applicant would appreciate if the Examiner would advise the undersigned by telephone.

Respectfully submitted,

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